REVIEW OF CRANIAL COMPUTED TOMOGRAPHY IN PATIENTS REFERRED TO KENYATTA NATIONAL HOSPITAL - A DESCRIPTIVE CROSS SECTIONAL STUDY

A dissertation submitted in part fullfilment for the degree of:

MASTER OF MEDICINE IN DIAGNOSTIC RADIOLOGY

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This distertion is my orginal work and has not been presented for a degree in any other university.

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With love, to my wonderful wife **KHADIJA S.,** my lovely son **Allan** whose support and encouragement are deeply apprecited.

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CONTENTS

SUMMARY

Morphological brain and skull abnormalities are fairly common; however, they are often difficult to diagnose. By using specific imaging criteria, one may readily diagnose these abnormalities. In this study an attempt has been made to illustrate the spectrum of imaging findings seen on computed tomography (CT), in the evaluation of brain abnormalities such as; congenital malformations, hydrocephalus, atrophic conditions, vascular and traumatic lesions. A total of 200 patients were considered in this study with Male : Female ratio of 1.3:1. 123(61.5%) were in-patients while 77(38.5%) were out-patients. The age of patients ranged from 4 months to 90 years. Most of patients in the study had provisional diagnosis indicated by referring clinician as; Congenital brain lesions (15.5%), Raised intracranial pressure (23.5%), Brain tumours (13%), Vascular lessions (6%), Infection and Infestations (9%), Traumatic brain lesions (15.5%) and other conditions (17.5%).

Evaluation of the types of brain lesions referred to KNH using C.T. and their association with demographic data (age, sex, and region referred from) is established.

Views on the accuracy of the provisional diagnosis given by the referring clinician from the wards or out-patient clinics are discussed. It is hoped that the result of this study may influence the use of CT by physicians looking after patients with brain and skull abnormalities.

INTRODUCTION

Neuroradiology has passed through several phases since it began soon after Roentgen's discovery of x-rays (1895). From 1896 to 1918 conventional radiography (simple x-rays) remained the only practical mode of imaging the brain.

In conventional radiography, three dimensional objects are viewed in two dimensions, that is, the complex shape, internal structure and anatomic relationships of organs are reduced to a flat film. This results in superimposition of shadows representing various body structures. In 1963 conventional tomography, the most effective method of separating confusing shadows, was found. This is a cross-sectional technique excluding confusing superimposed structures from the image displaying only two physical dimensions on the two dimensional film (1,2,3,4).

Conventional tomography has been of limited value as a method of examination in patients with intracranial lesions because it is associated with generally poor image contrast, and it has not been readily applicable to the generation of images in the transverse plane (11).

A new method of forming images from x-rays was developed and introduced into clinical use by the British physicist Godfrey Hounsfield in 1972, and is referred to as Computed Transmission Tomography, Computed Tomography (CT), or Computerised Axial Tomography (CAT) (11). It resulted in 1979 in the Nobel prize for medicine being awarded jointly to Dr. Hounsfield and Professor A.M. Cormack (12).

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In computed tomography the x-ray output is collimated to a very narrow beam. While passing through the patient it is partially absorbed, and the remaining photons of x-ray beam fall on radiation detectors instead of x-ray film. The detector response is directly related to the number of photons impinging on it and so to tissue density, since a greater proportion of x-ray photons passing through dense tissue are absorbed by the less dense tissues. These can be quantified and recorded digitally.

The information is fed into a computer which produces different readings as the x-ray beam is traversed around the subject. This can be presented as a numerical read out representing as absorption in each tiny segment of the section traversed. This information can also be presented in analogue form as a two dimensional display of the matrix on a screen where each numerical value is represented by a single picture element (pixel).

The more modern machines have improved the resolution by diminishing the size of each pixel. Modern machines achieve 320 x 320 matrix (12). The modern machines use a fan beam of x-rays and multiple detectors.

The advantage of the CT scanner is its high sensitivity to small differences in x-ray attenuation. This is partly accomplished by avoiding imaging superimposed structures which is also termed STRUCTURAL NOISE.

CT also displays slight attenuation differences as well because of the high percentage of photons detected, and because the contribution of non-useful scattered x-rays is reduced.

The most extensive application of computerized tomography (CT) has so far been in the examination of the head. The special attributes of high contrast resolution has enabled the visualization of minute differences in intracranial soft tissue structures to an extent completely unknown before the advent of CT.

In this technique, Computerised tomography (CT) has played a very big role in neuroradiology and interventional radiology. CT is a non-invasive, rapid examination, where, small differences in tissue attenuation not recorded by conventional radiography can be shown (18,20). Since the introduction of CT scanning, there has been a remarkable revolution in medical treatment of patients.

Computed tomography of the brain (CT) is a radiologic innovation of major importance in the detection and localisation of intracranial disease (18). Many patients have been saved or their quality of life improved as a result of the accurate diagnosis provided by CT.

In this technique the cranium is scanned 180 times at different angles by a narrow x-ray beam. Differential absorption by tissues in contiguous slices is calculated by a computer and presented a series of images of structure in the brain. This method is capable of revealing a remarkable amount of anatomical and pathological information and is rapidly gaining wide acceptance as an important and clinically useful modality (2).

At Kenyatta National Hospital, the CT scanner has been used since 1992. However, no studies have previously been undertaken to establish or to evaluate the types of brain lesions mostly referred to KNH. The purpose of this study is to evaluate the types of brain pathology mostly referred to KNH, to determine the commonest indications for computerised tomography scanning of the head in KNH and if there is any pathological association with the patient's area of referral. Apart from providing additional data on brain pathology the findings of the study are expected to give a correlation between CT final diagnosis with the physician's provisional diagnosis i.e. certainty of diagnosis.

LITERATURE REVIEW

Computerised tomography (CT) has significantly changed attitudes and allayed fears of non-diagnosis and misdiagnosis. The brain is no longer within a "box" that can be definitively searched only by morbid violation (angiography, pneumography, surgery or autopsy). More precisely, CT of the brain and its coverings has afforded in assessing the acute and chronic effects of head injury because of:

- The capacity to define an extracerebral process and to offer characterization of its compartmentalisation, nature and possible duration.
- An assessment of the degree of brain edema and related abnormalities; intracerebral haematoma, contusion, ventricular compression or ventriculomegally.
- The capacity to re-examine the patient expediently if any sudden change in neurological status supervenes.

As a result of such specificity and multiplicity of accurate diagnosis, the surgical management of head trauma has advanced greatly (21).

Several authors have reviewed computed tomography of the head with regard to various causes: DeSousa (3) found that head injury was a common problem in Kenya and that CT scanning was a useful imaging modality for evaluation of the problem. Road traffic accidents accounted for the majority of trauma (52.5%) followed by assault (28.1%) and falls (10.6%).

Intracranial haemorrhhages were common findings. Contusion injuries and generalised brain oedema were also frequently seen. Midline shift, compression of basal cisterns and sub-arachnoid haemorrhage were all found to be more frequent in patients with severe coma.

Significant intracranial pathology was often associated with the absence of skull vault fracture, and this emphasises the superiority of CT over plain skull films.

Strehlau (6) from her study done at the M. P. Shah and Aga Khan hospitals in Nairobi, reported that primary brain tumours were the commonest intracranial lesions observed and accounted for 87%. The next common intracranial lesion was haemorrhage following trauma. Hydrocephalus was found in 19% (70% were secondary to obstructing masses, 10% due to brain atrophy, 10% due to aqueductal stenosis and 10% had no demonstrable cause shown).

The beneficial influence of computed tomography (CT) on the diagnosis and management of intracranial infection and tumours was established (5). CT provides valuable management information that can be obtained in no other way. Correct diagnosis both regarding satisfactory resolution and complications depends on several enhanced examinations.

The blood brain barrier is not only of academic interest to the radiologist but is, above all, of clinical importance. In the diagnostic work-up of patients with suspected brain tumour or abscess the use of isotope scanning and contrast enhancement, after injection of iodinated contrast medium in computerised tomography, (CT) depends on the existence of this barrier (8).

There is a perivascular and intercellular space in certain brain tumours into which the contrast medium diffuses and gives rise to this enhancement. The presence of the perivascular and intercellular space in brain tumours is an important factor in diagnosing a brain tumour in radionuclide imaging and CT (8).

CT scanning is an important initial method of studying tumours of the cerebello-pontine angle, though good plain film examination laminography remain essential to proper evaluation. If typical bone changes are present and CT scans are clearly positive, angiography and pneumoencephalography may be avoided. Radionuclide studies would be useful only in those cases in which the CT scan is unsatisfactory. The roles of pneumoencephalography and positive contrast cisternography in the evaluation of smaller tumours remain minor.

A study done by Probst (9) on brain deformities, hydrocephalus and atrophic conditions showed that CT provides information which cannot be obtained with other neuroradiologic methods. In many situations it can completely replace encephalography and angiography. In post traumatic conditions CT may give more complete information about intra and extracerebral haematoma than angiography with loss of less time and less stress to the patient. The same applies for vascular lesions, but angiography will often be necessary for a detailed understanding of vascular pathology.

The ability of computed tomography (CT) to directly visualise brain parenchyma and its derangements has made it the diagnostic procedure of choice in the early evaluation of patients with stroke. Such patients constitute a large number of referrals for CT in most radiologic practices, since approximately 50% of all adult patients in neurological wards are admitted with symptoms referable to cerebrovascular disease (21).

The screening role of CT in cerebral infarction was established early, since the sensitivity of this examination approaches 98% in studies obtained after the first 48 hours of insult (23).

Because of the improved spatial and contrast resolution of current generation scanners, it was found that 76% of the studies obtained within 24 hours of documented infarction showed positive CT findings in a region correlating with the major clinical deficits. In fact, over half of patients had positive CT findings within the first 12 hours of symptom onset (23).

In the evaluation of infants and children with macrocephaly, the distinction between benign macrocephaly and hydrocephalus is critical because the prognosis and management of these two disorders are so radically different. Computed tomography (CT) offers a new, relatively non invasive method for evaluating children with macrocephaly as shown by Bahr and Hodges (26). CT is useful in determining ventricular size and shape as well as the amount of cerebral cortex present. In evaluation of suspected hydrocephalus, CT can rule out subdural effusion or haematoma, porencephalic cyst and arachnoidal cyst (26).In their analysis which was limited to 40 patients, hydrocephalus was a relatively common disease with an incidence of 2.5 per 1,000 infants (26).

The study (26) suggests that CT substituted substantially for two radiodiagnostic procedures. Pneumoencephalography was utilised significantly less after CT. This substitution is particularly important because pneumoencephalography, a procedure of comparable diagnostic efficacy to CT (26), is associated with definite morbidity and even mortality (26). By contrast, CT is relatively non invasive and has a low morbidity (26).

One significant benefit of CT is a decrease in hospital charges and occupancy by shortening the time for diagnostic studies as projected by several authors (32, 34, 35). This has been supported by data which show decreased average length of hospitalization and decreased hospital costs for comparable groups of patients with extracerebral fluid collections and brain tumours after installation of CT (36).

RATIONALE

The need for undertaking this study were:

a) Results from the study would add knowledge to what is already known about early and good evaluation of the patient by the physician. This would help in the planning for the proper management of the patient.

b) The study has attempted to establish the pattern of brain pathology and where the majority of referred patients come from (i.e whether they are in-patients or from out-patient clinics) in order to minimize workload and probably use the information from this study to recommend ways of selecting patients for head CT.

OBJECTIVES

1. To identify the types of brain lesions mostly referred to Kenyatta National Hospital.

2. To evaluate the distribution of provisional diagnosis, CT diagnosis and diagnostic accuracy of patients with various brain pathologies.

INCLUSION CRITERIA

- Only patients referred for CT examination of the head were included in the study.
- Only patients aged between 4 months and 90 years were studied.

EXCLUSION CRITERIA

- Patients with no information necessary for completion of the data sheet.

MATERIALS AND METHODS

This study was done at the Kenyatta National Hospital X- Ray department on patients referred for CT examination of the head from January 1994 to January 1996. The CT examinations was performed using a Phillips Tomoscan CX/Q machine which is a 3rd generation CT scanner manufactured in 1991.

This was a descriptive cross-sectional study. The research design is shown in the patient sample (appendix A).

METHODOLOGY

Most patients referred for computed tomography of the head were scrutinized at different levels of patient management in clinics, wards, and finally by the investigator with the consultant radiologist in the CT examination room.

For 100 patients data required was readily available from the CT request form used by the referring clinician, after which final CT findings were recorded after discussing with an experienced radiologist. For the other 100, the information required which was not available from the request form was obtained from the patient. Each group had an equal number of males and females, and also an equal number of adults and children as the research design indicated (appendix A & B).

Each case was assigned a case number from 1 to 200 which was recorded on the data sheet attached (appendix C).

Further information was obtained by reviewing hospital records; including CT scans and communication with an experienced radiologist who may not have been involved in the original patient work-up. All the information was recorded on the data sheet attached and the findings recorded in tables as shown below.

<u>DATA ANALYSIS</u>

The data was coded and entered into an IBM Compatible Micro-computer using *dBase* software. Data cleaning was carried out to check for completeness of data entry and ensure that the data was entered correctly. The actual analysis was carried out using the *Statistical Package for Social Sciences (SPSS)*. Statistical analysis involved descriptive statistics, Chi-Square and a test of proportions (10)

RESULTS

A total of 200 patients records on provisional diagnosis and CT diagnosis were reviewed. There were 113 (56.5%) males and 87(43.5%) females giving a male: female ration of 1.3:1.

The mean age was 24.69 years with a standard deriation of 23.4 years with age randing from 4 months to 90 years. The males had a mean age of 25.62 years (S.d.25.34) and age ranged from 7 months to 90 years while females had a mean age of 23.49 years (S.d.20.69) and their age ranged from 4 months to 75 years the distribution of age is given in Fig. 1.

Slightly over a half of the patients came from Central Province (52.5%).

Tables 2 gives the distribution of signs and symptoms that the patients presented with at the hospital. Majority presented with convulsion (26%) followed by hemiparesis (14.5%) and headache (14%).

From congenital lesions, provisional diagnosis, 3 cases were diagnosed by CT. One as raised intracranial pressure, one as tumour and the other as infection and infestation. Three cases of raised intracranial pressure by provisional diagnosis were classified - one as infection and infestation, one as traumatic brain lesion and the other as others.

Condition by CT findings, two tumours by provisional diagnosis were found by CT findings to be one vascular lesion and the other traumatic brain lesion. Two vascular lesions by provisional diagnosis were found by CT findings to be infection and infestation. One infection and infestation by provisional diagnosis was found to be traumatic brain lesion by CT findings.

Of traumatic brain lesions by provisional diagnosis, CT findings found two of them one to be vascular lesion and the other to be infection and infestation. Of other conditions, there were no provisional diagnosis given and CT findings found 3 to be tumours, 3 to be infection and infestation and the rest 25 were classified as others.

There was an almost perfect agreement between provisional diagnosis and CT findings going by Cohen's Kappa value (which was 0.86) which is used to measure agreement between two methods or observers.

There were 35 cases that had normal CT findings and their provisional diagnosis were 10 raised intracranial pressure, 3 tumours, 2 vascular lesions, 3 infection and infestation, 8 traumatic brain lesion and 9 other conditions.

Figure 2 and 3 shows distribution of provisional diagnosis by sex while figure 4 shows distribution of CT findings by sex.

There was no significant difference in sex distribution among provisional diagnosis (X^2_6 = 5.28, P = 0.51) and among CT final diagnosis X^2_7 = 6.69, P = 0.46)

TABLE 1: Distribution of patients by area referred from.

Area referred from	≤ 14 yrs	≥ 15 yrs	TOTAL	%
Central Province	55	50	105	52.5
Nairobi area	03	11	14	07.0
Western Province	10	08	18	09.0
Nyanza Province	16	11	27	13.5
Rift Valley Province	03	04	07	03.5
Coast Province	00	01	01	00.5
Eastern Province	13	14	27	13.5
Other countries	00	01	01	00.5
TOTAL	100	100	200	100.0

Table 2: Distribution of signs and symptoms that patients presented with at the hospital.

	SIGNS/SYMPTOMS	ADULT	CHILDREN	TOTAL FREQUENCY	%
1.	Convulsions	15	37	52	26.0
2	Diplopia	01	02	03	01.5
3	Poor vision	01	04	05	02.5
4	Headache	21	07	28	14.0
5	Fever	01	11	12	06.0
6	Vomiting	04	07	11	05.5
7	Weakness upper/lower limbs	04	06	10	05.0
8	hemiparesis	12	17	29	14.5
9	Quadriparesis	00	01	01	00.5
10	Hemiplegia	13	04	17	08.5
11	Proptosis	04	01	05	02.5
12	Increased head size	00	12	12	06.0
13	Ataxia	06	01	07	03.5
14	Aphasia	04	06	10	05.0
15	Papilloedema	02	01	03	01.5
16	Abnormal behaviour	14	01	15	07.5
17	Facial palsy	04	05	09	04.5
18	Ear discharge	02	01	03	01.5
19	Ptosis	02	01	03	01.5
20	Loss of memory	01	00	01	00.5
21	Nystagmus	01	00	01	00.5
22	Dizziness	01	00	01	00.5
23	Hand tremors	02	01	03	01.5
24	Focal twitching	01	00	01	00.5
25	Urinary incontinence	03	01	04	02.0
26	Dysphasia	04	01	05	02.5

TABLE 3: Distribution of provisional diagnosis, CT diagnosis and percent diagnostic accuracy of study patients.

Type of diagnosis	No. of Provisional	No. of CT	No. of CT diagnoses agreeing with provisional diagnosis	Percent diagnostic accuracy (%)
Congenital lesions	25	22	22	88.0
Raised intracranial pressure	42	40	39	92.9
Tumours	22	24	20	90.9
Vascular lesions	09	09	07	77.8
Infections & infestations	11	18	10	90.9
Traumatic brain lesions	25	26	23	92.0
Other conditions	31	26	25	80.6
Total	165	165	165	

TABLE 4: DISTRIBUTION OF PROVISIONAL DIAGNOSIS NOT CONFIRMED BY C.T. BY PLACE OF REFERRAL.

PROVISIONAL DIAGNOSIS	PLACE OF EFERRAL					
	OUTPATIENT number	%	INPATIENT number	%	TOTAL number	%
Congenital lesions	2	66.7	1	33.3	3	5.5
Raised intracranial pressure	2	66.7	1	33.3	3	5.5
Tumours	2	100	0	0	2	3.7
Vascular lesions	2	100	0	0	2	3.7
Infection & infestation	0	0	1	100	1	1.8
Traumatic brain lesions	1	50	1	50	2	3.7
Other conditions	4	66.7	2	33.3	6	11.1
Normal	27	77.1	8	22.9	35	64.8
TOTAL	40	74.1	14	25.9	54	

FIG 1: AGE DISTRIBUTION OF STUDY PATIENTS

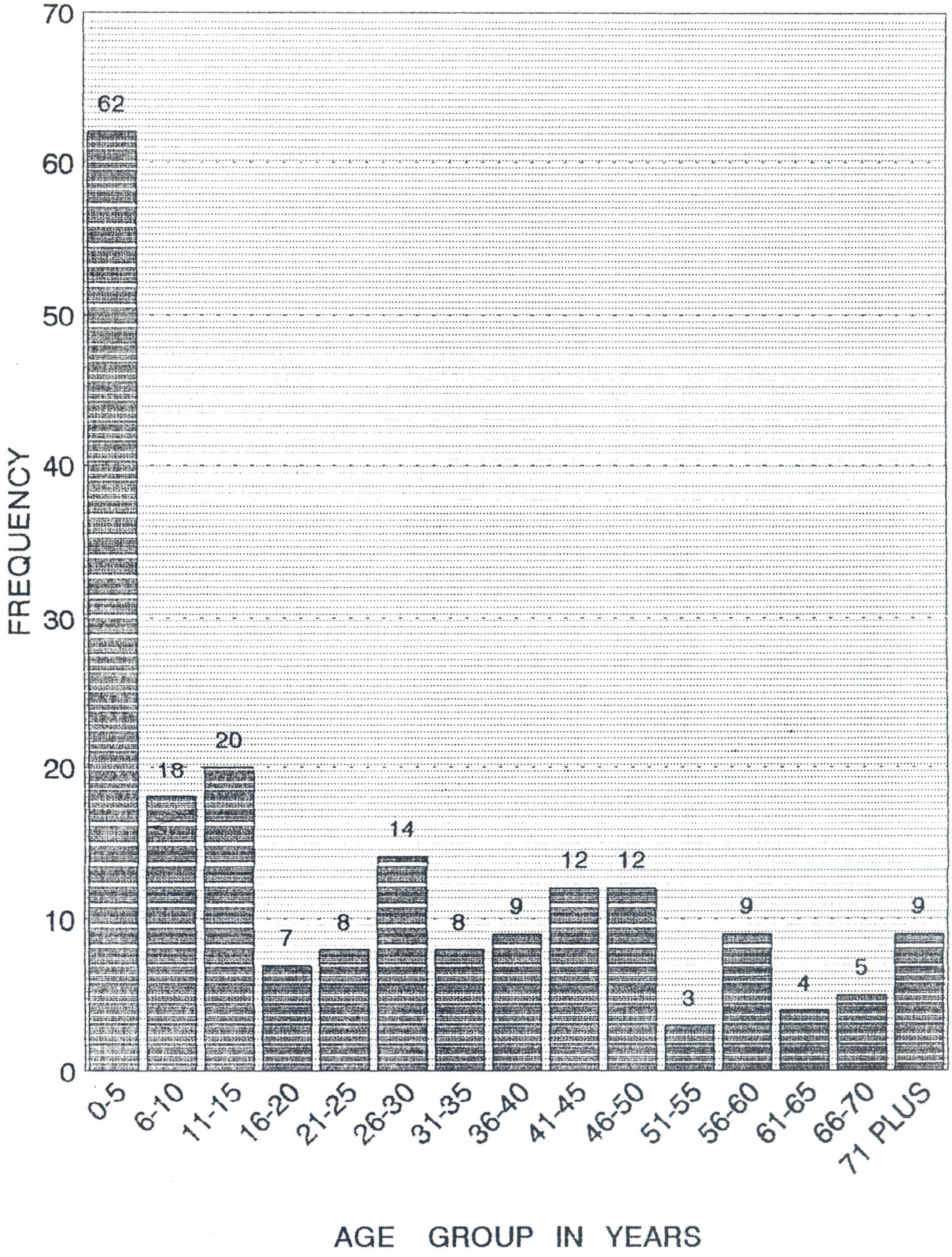
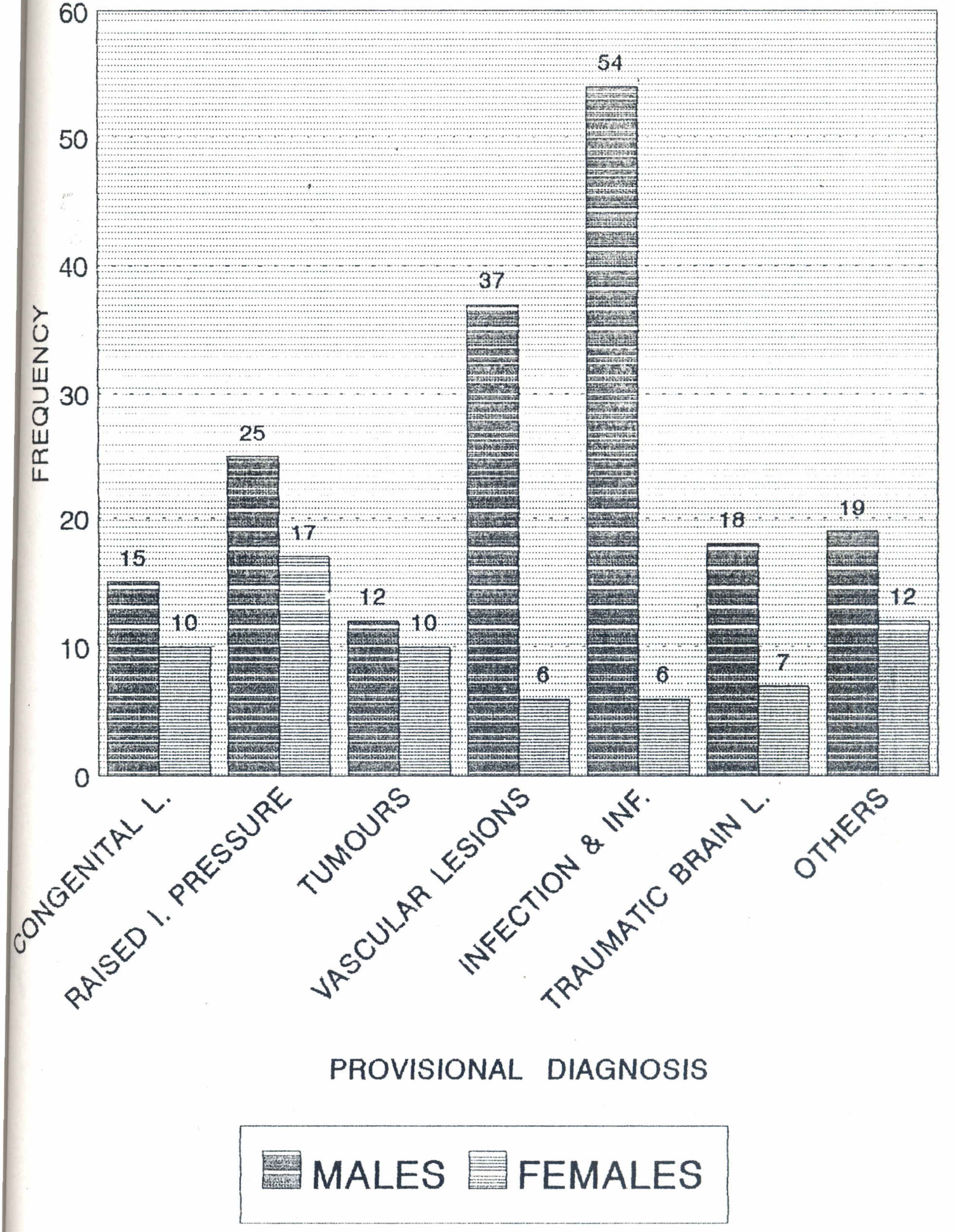
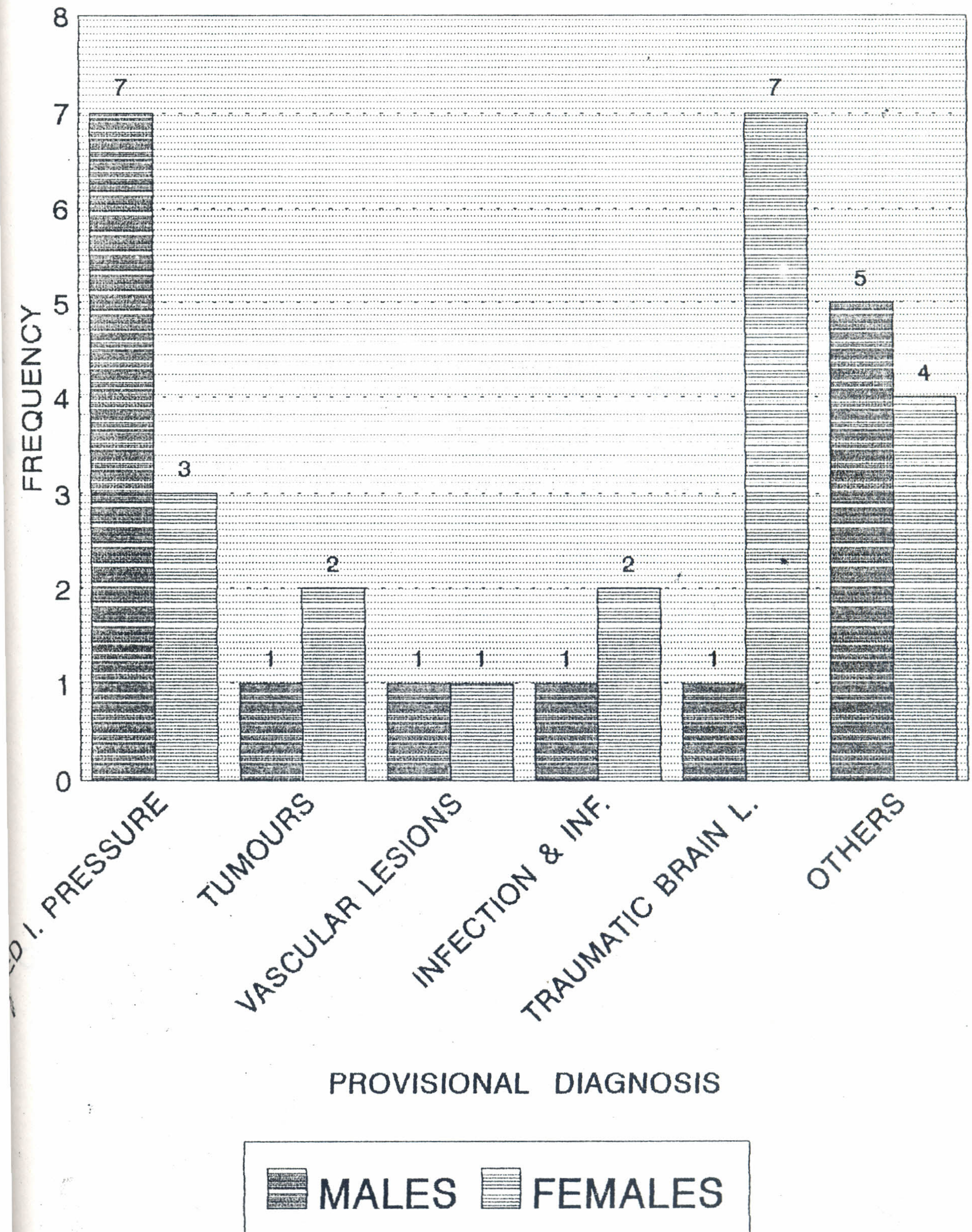


FIG 2: DISTRIBUTION OF PROVISIONAL DIAGNOSIS BY SEX



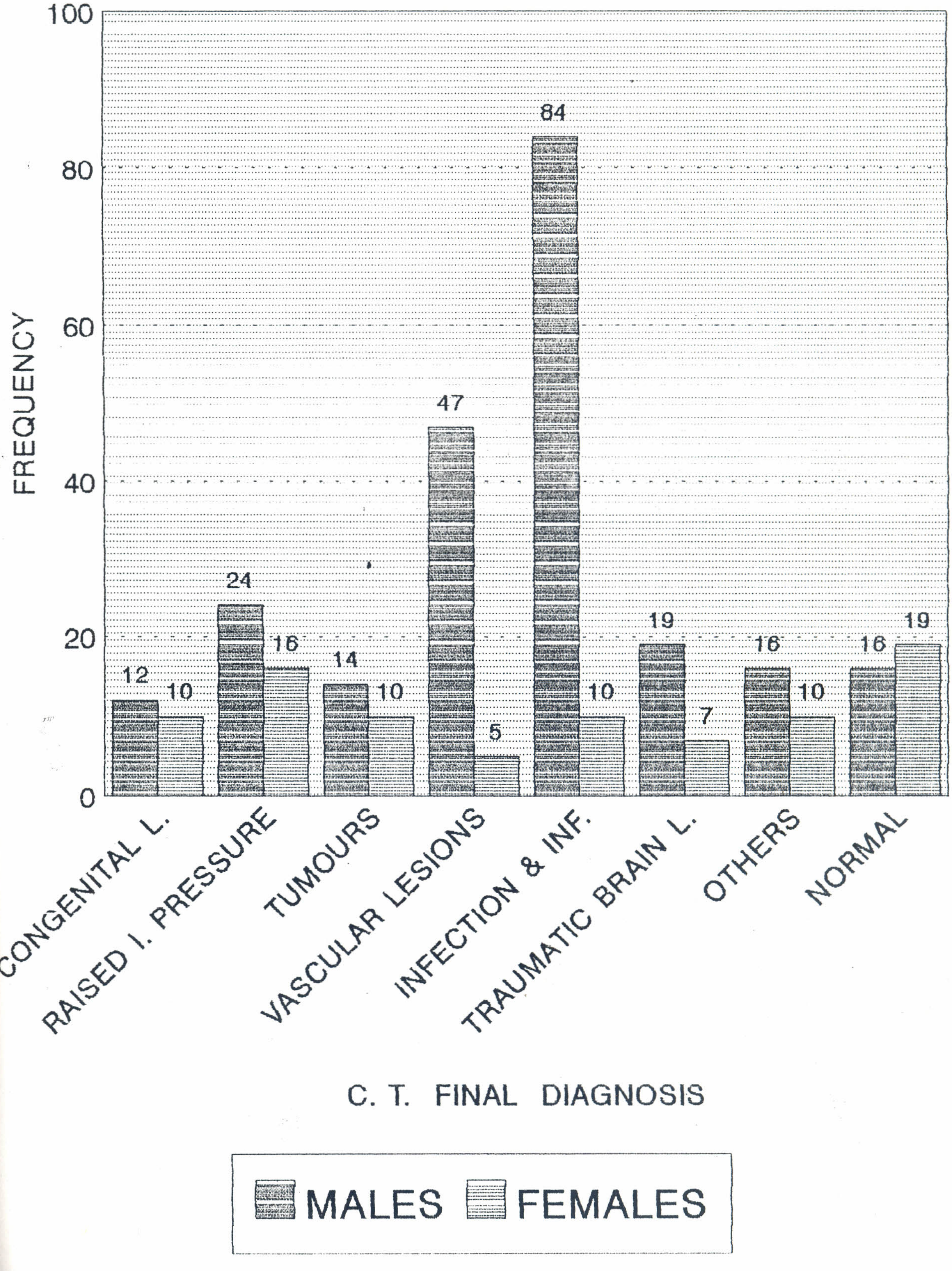
RACRANIAL; L: LESIONS; INF: INFESTATION

FIG 3: DISTRIBUTION OF PROVISIONAL DIAGNOSIS BY SEX FOR NORMAL C.T.'s



ACRANIAL; L: LESIONS; INF: INFESTATION

FIG 4: DISTRIBUTION OF C.T. FINAL DIAGNOSIS BY SEX



RACRANIAL; L: LESIONS; INF: INFESTATION

DISCUSSION

Computed tomography of the brain already has an important place in medicine. Volumes of literature attest to clinical interest in this procedure [27]. A positive diagnosis can be obtained in a very high percentage of patients as it records much more definite and detailed information than can be obtained from other diagnostic procedures.

Determination of the impact of CT on patients with brain lesions is important and may assist decision making about the proper utilization of CT especially in the third world countries.

Many will question that CT has made diagnosis simpler and gives qualitatively superior data to most of the more invasive studies [28,29].

One additional benefit of CT may be decrease in hospital charges and occupancy by shortening time for diagnostic studies as projected by several authors [30].

Decreased costs for neurodiagnostic workup in suspected hydrocephalus are shown by Larson et al [25].

It has been found that the availability of other imaging modalities such as MRI and Ultrasound (for neonates) would be of great help in eliminating ionizing radiation procedures such as CT [31].

In this study, a total of 200 patients records on provisional diagnosis and CT diagnosis were reviewed. There were 113 (56.5%) males and 87 (43.5%) females giving a male: female ratio of 1.3:1.

The impact of CT in brain deformities especially hydrocephalus; atrophic conditions, most infratentorial tumours and the inflammatory process, CT provides information which cannot be obtained with other neuroradiologic methods.

Table 3 displays the distribution of provisional diagnoses, CT diagnosis and percent diagnostic accuracy of study patients.

In analysing the indications of CT examination, it was seen that majority of patients referred for CT of the head were raised intracranial pressure (S.O.L.) (25.5%). The second group of patients were referred following traumatic brain lesions (15.2%).

Several authors [32,33] have obtained a diagnostic accuracy of approximately 95% in early days of CT scanning. The false positive and false negative cases were found to be nearly equally divided in most series.

In this study, there is an almost perfect agreement between provisional diagnosis and CT final diagnosis. The diagnostic accuracy is highest for brain lesions with raised intracranial pressure (92.9%), followed by traumatic brain lesions (92%) and both brain tumours and brain infections with 90.9% diagnostic accuracy each.

The accuracy of provisional diagnosis given by the referring clinician from the wards or out-patient clinics shows that, of all those referred from out-patient 51.9% [40/77] had false provisional diagnosis compared to only 11.4% [14/123] from in-patient. This difference was highly statistically significant (Z= 6.3; P<0.001).

CONCLUSION AND RECOMMENDATIONS

Computed tomography of the brain (CT) is a radiological innovation of major importance in the detection and localisation of intracranial disease. Many patients have been saved or their quality of life improved as a result of the accurate diagnosis provided by CT.

All patients attending brain CT examination are referred by Clinicians who make their decision according to patients signs and symptoms. Certain symptoms are so vague that on their own they should not warrant a request for cranial CT examination; therefore from this study the following are recommendations:

- Clinicians should have more frequent consultations with radiologists in order to make the best use of cranial CT examination.

- Clinicians in the casualty or out-patient clinics should first refer their patients to the appropriate clinics, e.g. Neuro-surgical, Paediatric etc. if they think that their patients need CT examination, and from there patients will be screened for CT examination.

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- Clinicians should do all the necessary diagnostic procedures and be sure that by requesting CT examination added information will be found.

- Radiologist who make the bookings for brain CT should thoroughly scrutinize the clinical information on the request form and if this information is inadequate the booking should not be made and the referring clinician be consulted.

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APPENDIX A

THE PATIENT SAMPLE

The convenient sample size was determined from the formula shown below. Patients in this study were either in- or out-patients.

Method of obtaining patient sample size (n):

$$n = \frac{[z_{1-\alpha}]^2 \; p(1-p)}{d^2} \qquad (10)$$

Whereas; n = desired sample

z = confidence level = 5.85

p = proportion of CT cranial pathology ± 40%

α = level of significance 5%

d = accepted range of deviation from the real situation or desired degree of precision, set at 10%

$$n = \frac{(5.85)^2 \;\; x \;\; 0.4 \;\; x \;\; 0.6}{(0.1)^2} = 200.5$$

To account for the study, a total number of 200 patients was monitored.

APPENDIX B

RESEARCH DESIGN

Patients attending CT
examination of the head at KNH

Identification of patients

All patients between 4 months
and 90 years

Random selection

Patients are divided into
Age group 4 months-13 years - Children
Age group 14-90 years - Adults

Random selection:
equal No. of M & F

100 patients from each group

NB: M & F mean Male and Female respectively.

APPENDIX C

DATA SHEET

CASE NUMBER...........

1. Name________________________ Sex____________ Age_____________

Residence_________________________

2. Where is the patient referred from?

(i) In-patient, Ward_________ Out-patient, Clinic_________?

Private_______?

Referred______?

3. Provisional Diagnosis____

____

____

____

4. Clinical features.

Signs and symptoms____

____

5. Other conventional or neuroradiological findings________________

____

____

____

6. Final CT diagnosis____

____

____

____